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(54) TITLE OF THE INVENTION
SEMI-TRANSPARENT MIRROR [Hantoukyoo]

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[Amendments: There are no amendments to this patent. Translator's note]

[Note: All names, addresses, company names, and brand names are translated in the most common manner. Japanese language does not have singular or plural words unless otherwise specified with numeral prefix or general form of plurality suffix. Translator's note]

SPECIFICATION

1. TITLE OF THE INVENTION
SEMI-TRANSPARENT MIRROR

2. CLAIMS

According to a semi-transparent mirror that is formed by an alternate lamination of a dielectric body with high index of refractivity and a dielectric body with low index of refractivity, that remain transparent at visible wavelength region, on a substrate, the semi-transparent mirror is characterized by the fact that total number of layers (L) being 7 ~ 10 layers, and at the same time, when it is referenced in the order of first layer, second layer ..... starting from a side where it faces air toward substrate side, in the case of total number of layers (L) being of even number, classification is made in such manner that from the side where it faces air to the (L)/two layers to be group A while the layers that are at substrate side beyond that to be group B ; and in the case of total number of layers (L) being of odd number, classification is made in such manner that from the side where it faces air to the (L+1)/two layers as group A while the layers that are at substrate side beyond that to be group B; and the optical film thickness of the layer showing the maximum optical film thickness among [the layers of] group A being smaller than the optical film thickness of the layer that shows minimum optical film thickness among [the layers of] group B.

3. DETAILED EXPLANATION OF THE INVENTION

FIELDS OF INDUSTRIAL APPLICATION

This invention relates to a semi-transparent mirror that is used to split incidental lights to transmitted lights and reflected lights, and in further detail, it relates to the semi-transparent mirror suited as the main mirror of a single-lens reflex camera.

PRIOR ART

According to a single-lens reflex camera, it has been generally known that photometry for purpose of exposure control or detection of focal point is conducted through arrangement of a photo-detector element underneath a mirror box. In such case, it is necessary that the main mirror of single-lens reflex camera is semi-transparent.

Conditions suited for such semi-transparent mirror include not only possible observation of a finder image in as bright as possible manner, but also it is necessary to provide a sufficient quantity of light to the light-detector element for purpose of exposure control or detection of focal point. Figure 9 illustrates a cross sectional view that shows structure of a single-lens reflex camera. According to this Figure, the lights that are transmitted through an object lens (2) are split into the lights that are reflected by the main mirror (4) comprising semi-transparent mirror and proceed toward a view finder system that is equipped with a focal point plate (6), a pentagonal prism (8) and an eye piece (10), and the lights that are transmitted through the main mirror (4) and are reflected at an auxiliary mirror ant proceed to the light-detector element (16) via lens (14); and at this time, as said semi-transparent mirror, the one that uses a metal and the one that uses dielectric body may be mentioned. However, as the semi-transparent mirror that uses metal shows absorption of lights by the metal, it shows a defect of poor efficiency. On the one hand, the semi-transparent mirror that uses dielectric body shows a very good efficiency as long as there is no absorption by the dielectric body itself that is used in the visible region..

And therefore, although a semi-transparent mirror in which multiple numbers of dielectric body are laminated , and is used, it is recommended to increase the reflectance of semi-transparent mirror of the main mirror (4) to greater than transmissivity because it generally shows lower sensitivity to brightness of eyes compared to that of light-detector element (16). However, when reflectance is set to be too large, quantity of lights that enter light-detector element (16) becomes reduced in addition to increase in number of layers of the semi-transparent mirror to result in higher cost as well as difficulty of attaining spectral characteristic that is close to that of design value due to cumulative manufacturing errors. In addition, it presents a problem that may crack easily when number of the layer happens to increase.

For instance, semi-transparent mirror with components shown in the Table 1 is disclosed in the Japanese patent publication of Kokai Sho 53 [1978]-110541.

TABLE 1

	Refractive index	Optical film thickness
Air	1.0	
First layer	1.45	0.25 λ
Second layer	2.26	0.25 λ
Third layer	1.45	0.25 λ
Fourth layer	2.26	0.25 λ
Fifth layer	1.45	0.25 λ
Sixth layer	2.26	0.5 λ
Substrate	1.52	

The term λ shows designed wavelength.

However, according to such structure, as it is clear from the Figure 10 that illustrates this spectral reflectance characteristic, although nearly a flat spectral characteristic may be obtained at the entire visible region, merely about 50% of reflectance can be obtained, and that is not suited as the main mirror for a single-lens reflex camera.

PROBLEM POINTS SOLVED BY THIS INVENTION

Purpose of this invention is to offer a semi-transparent mirror that is suited for the main mirror of single-lens reflex camera that does not display above-explained defects.

MEANS USED TO SOLVE PROBLEM POINTS

Furthermore, in order to attain above-explained purpose, these inventors first of all discovered that it is good for the semi-transparent mirror that is used as the main mirror of single-lens reflex camera to show about 55 ~ 80% of reflectance over the entire visible region. [Note: The original document sometimes refers to the term visible region and visible wavelength region, and the translation is made in accordance to the terms used in the original document. Translator's note] This is because when reflectance happens to be 55 % or lower, view finder image becomes too dark, and when it happens to be 80% or greater, quantity of lights entering light-detector element becomes too few.

According to a semi-transparent mirror that is formed by an alternate lamination of a dielectric body with high index of refractivity and a dielectric body with low index of refractivity , that remain transparent at visible wavelength region, on a substrate, the semi-transparent mirror that is characterized by the fact that when total number of layers (L) are 7 ~ 10 layers, and at the same time, when it is references in the order of first layer, second layer ..... starting from a side of air toward substrate side, in the case of total number of layers (L) being of even number, classification is made in such manner that from the side of air to the (L)/two layers to be group A, while the layers that are at substrate side beyond that to be group B; and in the case of total number of layer (L) being of odd number, classification is made in such manner that from the side of air to the (L+1)/two layers as group A while the layers that are at substrate side beyond that to be group B; and the optical film thickness of the layer showing the maximum optical film thickness among group A being smaller than the optical film thickness of the layer that shows minimum optical film thickness among group B, these inventors found that said semi-transparent mirror to show about 55% ~ 80% reflectance over the entire visible region explained above while its spectral characteristics remain flat.

And therefore, the essence of this invention is that according to a semi-transparent mirror that is formed by an alternate lamination of a dielectric body with high index of refractivity and a dielectric body with low index of refractivity, that remain transparent at visible wavelength region, on a substrate of which total number of layers (L) being 7 ~ 10 layers, and at the same time, when it is referenced in the order of first layer, second layer .... starting from aside of air toward substrate side, in the case of total number of layers (L) being of even number, classification is made in such manner that from the side of air to the (L)/two layers to be group A while the layers that are at substrate side beyond that to be group B; and in the case of total number of layers (L) being of odd number, classification is made in such manner that from the side of air to the (L+1)/two layers as group A while the layers that are at substrate side beyond that to be group B; and the optical film thickness of the layer showing the maximum optical film thickness among group A being smaller than the optical film thickness of the layer that shows minimum optical film thickness among group B.

That is to say, this invention is characterized by the fact that thickness of the layer at where it faces air is made thin while that of the layer at substrate side is made thick; and when this is expressed in a mathematical manner by identifying first layer, second layer ..... in the order from the side that faces air to substrate side, and by identifying optical film thickness of the (i)th number of layer as Ni, it will be as shown below.

$$_{max}\,[N_1, N_2, \ldots\ldots, N_k] < _{min}[N_{k+1}, N_{k+2}, \ldots. N_L]$$

However, k=l/2 (when L is of even number)

k=L/2 (when L is of odd number)

EXAMPLES

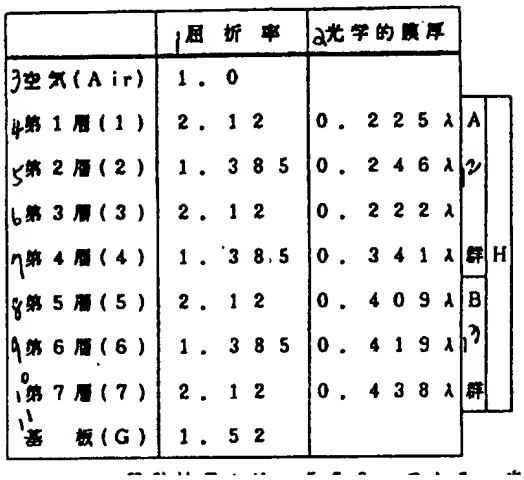
This invention's examples are explained below.

EXAMPLE 1

Figure 1 illustrates a cross sectional view of a structure of the example1 of this invention. According to this Figure, (G) shows a substrate, (Air) shows a layer that faces air, and the semi-transparent mirror (H) that consists of 7 layer structure in the order from the side that faces air to substrate side of first layer (1), second layer (2), third layer (3), fourth layer (4), fifth layer (5), sixth layer (6), and seventh layer (7); and group A (A) includes first layer (1) ~ fourth layer (4), and group B (B) includes fifth layer (5) ~ seventh layer (7). Furthermore, layers of 1,3,5 and 7 are of dielectric layers with high index of refractivity comprising dielectric body showing higher index of refractivity than that of the substrate (G), and layers of 2,4, and 6 are of dielectric layers with low index of refractivity comprising dielectric body showing lower index of refractivity than that of the substrate (G). Index of reactivity as well as optical film thickness of each layer is shown in the Table 2.

TABLE 2

1: index of refractivity, 2: optical film thickness, 3: air (Air), 4: first layer (1), 5: second layer (2), 6: third layer (3), 7: fourth layer (4), 8: fifth layer (5), 9: sixth layer (6), 10: seventh layer (7), 11: substrate (G), 12: group A, 13: group B



	1 屈折率	2 光学的膜厚		
3 空気(Air)	1.0			
4 第1層(1)	2.12	0.225λ	A	H
5 第2層(2)	1.385	0.246λ	群	
6 第3層(3)	2.12	0.222λ		
7 第4層(4)	1.385	0.341λ	群	
8 第5層(5)	2.12	0.409λ	B	
9 第6層(6)	1.385	0.419λ	群	
10 第7層(7)	2.12	0.438λ		
11 基板(G)	1.52			

At this time, designed wavelength λ is 550 nm; and incidental angle to the semi-transparent mirror part (H) is 45°. According to this example, either ZrO_2 or mixture of ZrO_2 and TiO_2 is used as a dielectric layer with high index of refractivity; and MgF_2 is used as dielectric layer with low index of refractivity. Furthermore, it is manufactured through an alternate lamination of a dielectric layer with high index refractivity and a dielectric layer with low index of refractivity on a substrate (G).

Spectral reflectance characteristic of this example is shown in the Figure 2 (I). As it is clear from the Figure 2, according to this example, it is possible to obtain the one showing a flat reflectance over entire visible region of 400 nm ~ 700 nm as well as 60% or greater average reflectance.

EXAMPLE 2

According to a 7 layer structure of the example 1, this example shows a dielectric layer with low index of refractivity being SiO_2 with 1.47 index of refractivity and dielectric layer with high index of refractivity being TiO_2 with 2.3 index of refractivity, and optical film thickness of each layer is adjusted accordingly. Structure of example 2 is shown in the Table 3.

TABLE 3

1: index of refractivity, 2: optical film thickness, 3: air (Air), 4: first layer (1), 5: second layer (2), 6: third layer (3), 7: fourth layer (4), 8: fifth layer (5), 9: sixth layer (6), 10: seventh layer (7), 11: substrate (G), 12: group A, 13: group B

	屈折率	光学的膜厚		
空気(Air)	1.0			
第1層(1)	2.3	0.159λ	A	
第2層(2)	1.47	0.219λ		
第3層(3)	2.3	0.231λ		
第4層(4)	1.47	0.244λ	群	H
第5層(5)	2.3	0.363λ	B	
第6層(6)	1.47	0.347λ		
第7層(7)	2.3	0.403λ	群	
基板(G)	1.52			

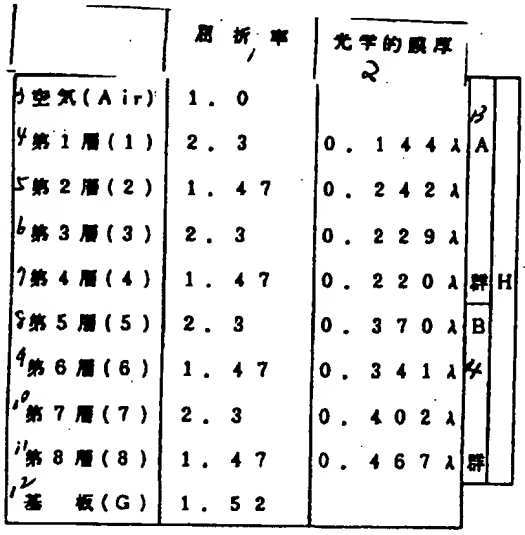
At this time, designed wavelength λ is 550 nm, and incidental angle to the semi-transparent mirror (H) is 45°. Spectral reflectance characteristic of this example is shown in the Figure 2 with line (II). As it is clear from the Figure 2, it is possible to obtain the one showing flat spectral characteristic as well as about 60% of average reflectance by this example also.

EXAMPLE 3

As illustrated with a cross sectional view in the Figure 3, this example shows a 8 layer structure that is composed in the order from the side that faces air to substrate side of first layer (1), second layer (2), third layer (3), fourth layer (4), fifth layer (5), sixth layer (6), seventh layer (7), and eighth layer (8). It goes without saying that the first layer (1) at the side that faces air is composed of dielectric body with high index of refractivity. According to this example, dielectric layers with high index of refractivity including (1), (3), (5), and (7) are each formed of TiO_2, and dielectric layers with low index of refractivity including (2), (4), (6) and (8) are each formed of SiO_2. Structure of this example is shown in the Table 4.

TABLE 4

1: index of refractivity, 2: optical film thickness, 3: air (Air), 4: first layer (1), 5: second layer (2), 6: third layer (3), 7: fourth layer (4), 8: fifth layer (5), 9: sixth layer (6), 10: seventh layer (7), 11: eighth layer (8), 12: substrate (G), 13: group a, 14: group B,



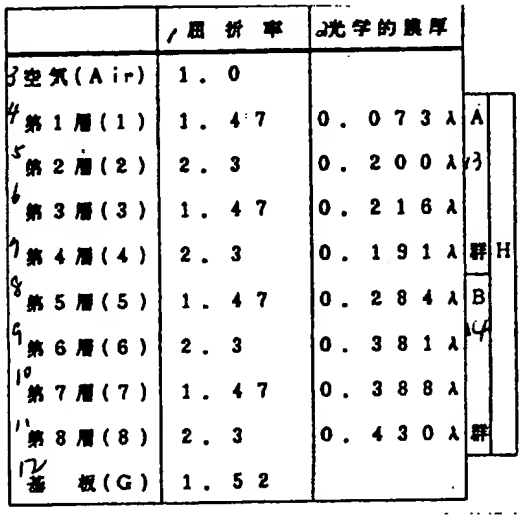
At this time, designed wavelength λ is 550 nm, and incidental angle to the semi-transparent mirror part (H) is 45°. Spectral reflectance characteristic of this example is shown with line (III) in the Figure 4. As it is clear from the Figure 4, it is possible to obtain the one with flat spectral characteristic and about 60% of average reflectance through is example also.

EXAMPLE 4

This example shows reversal of dielectric layer with low index of refractivity and dielectric layer with high index refractivity from those shown in the example 3; and optical film thickness of each layer is adjusted accordingly. Structure of the example 4 is shown in the Table 5.

TABLE 5

1: index of refractivity, 2: optical film thickness, 3: air (Air), 4: first layer (1), 5: second layer (2), 6: third layer (3), 7: fourth layer (4), 8: fifth layer (5), 9: sixth layer (6), 10: seventh layer (7), 11: eighth layer (8), 12: substrate (G), 13: group A, 14: group B



	1 屈折率	2 光学的膜厚		
3 空気(Air)	1.0			
4 第1層(1)	1.47	0.073λ	A	
5 第2層(2)	2.3	0.200λ	13	
6 第3層(3)	1.47	0.216λ		
7 第4層(4)	2.3	0.191λ	群	H
8 第5層(5)	1.47	0.284λ	B	
9 第6層(6)	2.3	0.381λ	14	
10 第7層(7)	1.47	0.388λ		
11 第8層(8)	2.3	0.430λ	群	
12 基板(G)	1.52			

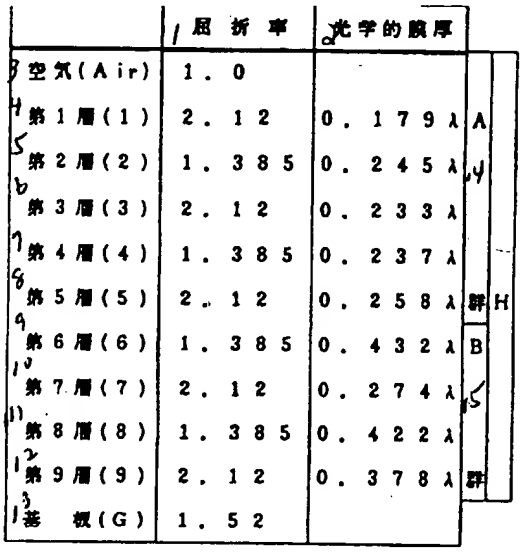
At this time, designed wavelength λ is 550 nm, and incidental angle to the semi-transparent mirror part (H) is 45°. Spectral reflectance characteristic of this example is shown with line (IV) in the Figure 4. As it is clear from the Figure 4, it is possible to obtain the one with flat spectral characteristic and about 60% of average reflectance through this example also.

EXAMPLE 5

As illustrated in the Figure 5, this example is an example of a 9 layer structure composed in the order from the air side of first layer (1), second layer (2), third layer (3), fourth layer (5), fifth layer (5), sixth layer (6), seventh layer (7), eighth layer (8) and ninth layer (9). According to this example, dielectric layers with high index of refractivity including (1), (3), (5), (7), and (9) are formed of ZrO_2, and dielectric layers with low index of refractivity including (2), (4), (6) and (8) are formed of MgF_2. Specific structure of this example is shown in the Table 6.

TABLE 6

1: index of refractivity, 2: optical film thickness, 3: air (Air), 4: first layer (1), 5: second layer (2), 6: third layer (3), 7: fourth layer (4), 8: fifth layer (5), 9: sixth layer (6), 10: seventh layer (7), 11: eighth layer (8), 12: ninth layer (9), 13: substrate (G), 14: group A, 15: group B



At this time, designed wavelength λ is 550 nm, and incidental angle to the semi-transparent mirror part (H) is 45°. Spectral characteristic of this example is shown with line (V) in the Figure 6. As it is clear from the Figure 6, it is possible to obtain the one with flat spectral characteristic and about 65% of average reflectance through this example also.

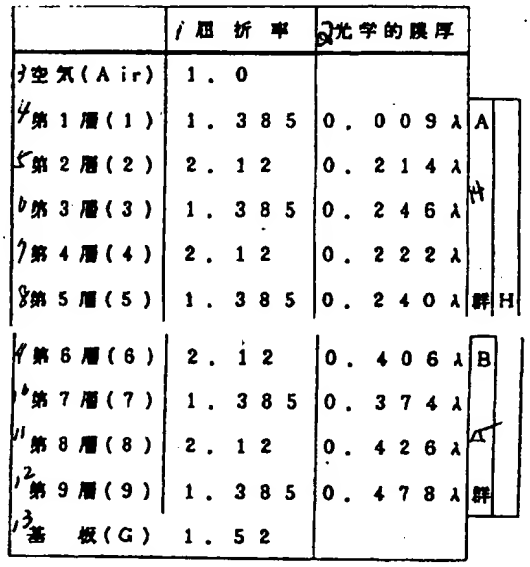
Furthermore, according to this example, it is all right to use a mixture of ZrO_2 and TiO_2 in the place of ZrO_2 as dielectric layer with high index of refractivity.

EXAMPLE 6

This example shows reversal of dielectric layer with low index of refractivity and dielectric layer with high index of refractivity as shown in the example 5; and optical film thickness of each layer is adjusted accordingly. Structure of the example 6 is shown in the Table 7.

TABLE 7

1: index of refractivity, 2: optical film thickness, 3: air (Air), 4: first layer (1), 5: second layer (2), 6: third layer (3), 7: fourth layer (4), 8: fifth layer (5), 9: sixth layer (6), 10: seventh layer (7), 11: eighth layer (8), 12: ninth layer (9), 13: substrate (G), 14: group A, 15: group B



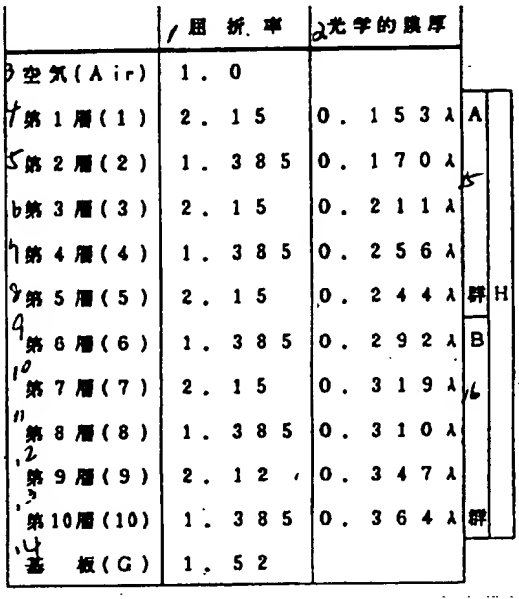
At this time, designed wavelength λ is 550 nm, and incidental angle to the semi-transparent mirror part (H) is 45°. Spectral characteristic of this example is shown with line (VI) in the Figure 6. As it is clear from the Figure 6, it is possible to obtain the one with flat spectral reflectance characteristic and about 60% of average reflectance through this example. Furthermore, this example uses either ZrO_2 or mixture of ZrO_2 and TiO_2 as dielectric layer with high index of refractivity, and MgF_2 as dielectric layer with low index of refractivity.

EXAMPLE 7

As illustrated in the Figure 7, this example is an example of a 10 layer structure that is composed in the order from the air side of first layer (1), second layer (2), third layer (3), fourth layer (4), fifth layer (5), sixth layer (6), seventh layer (7), eighth layer (8), ninth layer (9), and tenth layer (10), According to this example, dielectric layers with high index of refractivity including (1), (3), (5), (7), and (9) are composed of either CeO_2 or mixture of ZrO_2 and TiO_2, and dielectric layers with low index of refractivity including (2), (4), (6), (8), and (10) are composed of MgF2. Specific structure of this example is shown in the Table 8.

TABLE 8

1: index of refractivity, 2: optical film thickness, 3: air (Air), 4: first layer (1), 5: second layer (2), 6: third layer (3), 7: fourth layer (4), 8: fifth layer (5), 9: sixth layer (6), 10: seventh layer (7), 11: eighth layer (8), 12: ninth layer (9), 13: tenth layer (10), 14: substrate (G), 15: group A, 16: group B,



At this time, designed wavelength λ is 550 nm, and incidental angle to the semi-transparent mirror part (H) is 45°. Spectral reflectance characteristic of this example is shown with line (VII) in the Figure 8. As it is clear from the Figure 8, it is possible to obtain the one with flat spectral characteristic and about 70% of average reflectance through this example.

Furthermore, at this time, it is possible to use TiO_2, ZrO_2, CeO_2, ZnS, or these mixtures as dielectric layer with high index of refractivity, and MgF_2 or SiO_2 and the like as dielectric layer with low index of refractivity.

EFFECTS OF THIS INVENTION

As explained in details above, according to the semi-transparent mirror that is formed by an alternate lamination of a dielectric layer with high index of refractivity and a dielectric layer with low index of refractivity, that remain transparent at visible wavelength region, on a substrate, this invention is characterized by the fact that total number of layers (L) being 7 ~ 10 layers, and at the same time, when it is referenced in the order of first layer, second layer ..... starting from a side that faces air toward substrate side, in the case of total number of layers (L) being of even number, classification is made in such manner that from the side that faces air to the (L)/two layers to be group A while the layers that are at substrate side beyond that to be group B; and the case of total number of layers (L) being of odd number, classification is made in such manner that from the side that faces air to the (L+1)/two layers as group A while the layers that are at substrate side beyond that to be group B; and the optical film thickness of the layer showing maximum optical film thickness among group A being smaller than the optical film thickness of the layer that shows minimum optical film thickness among group B; and through such structure, it is possible to obtain nearly flat spectral reflectance characteristic over entire visible ray region in addition, to about 55% ~ 80% of average reflectance to give a semi-transparent mirror suited as the main mirror for single-lens reflex camera.

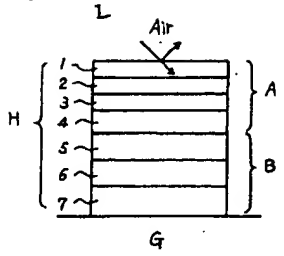
4. BRIEF EXPLANATION OF THE FIGURES

Figure 1 illustrates a cross sectional view that shows a film structure of this invention's example 1 and example 2; and figure 2 shows a graph that indicates its spectral reflectance characteristic; and Figure 3 illustrates a cross sectional view that shows a film structure of this invention's example 3 and example 4; and Figure 4 shows a graph that indicates its spectral reflectance characteristic; and Figure 5 illustrates a cross sectional view that shows a film structure of this invention's example 5 and example 6; and Figure 6 shows a graph that indicates its spectral reflectance characteristic; and Figure 7 illustrates a film structure of this invention's example 7; and Figure 8 shows a graph that indicates its spectral reflectance characteristic; and Figure 9 illustrates a cross sectional view that shows optical system of single-lens reflex camera; and Figure 10 shows a graph that indicates spectral reflectance characteristic of conventional example.

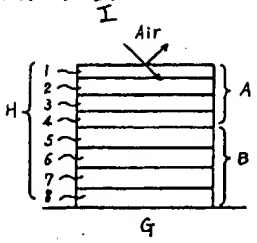
(1), (2) ..... ; first layer, second layer , ... (A): group A, (B): group B,

Figures 1 through 10
I: Figure, II: reflectance (%), III: wavelength,

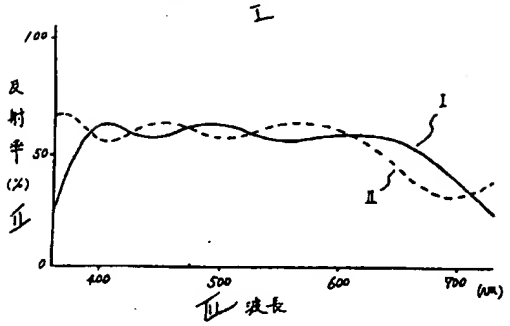
第 1 図



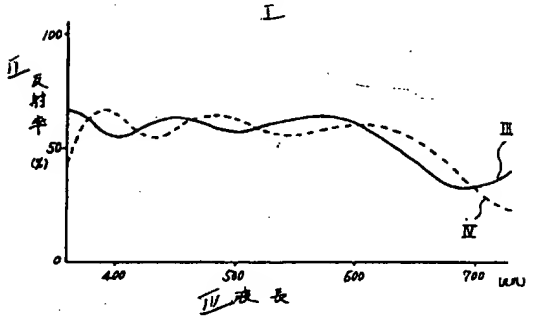
第 3 図



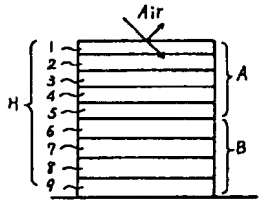
第 2 図



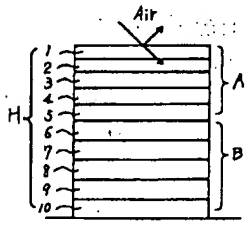
第 4 図



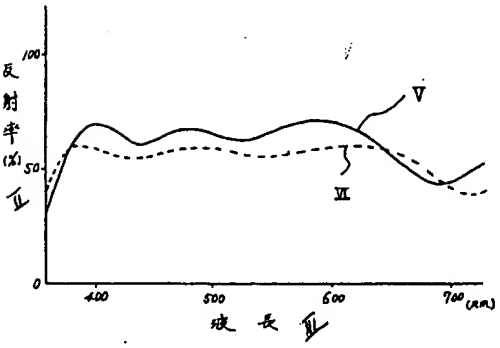
第 5 図



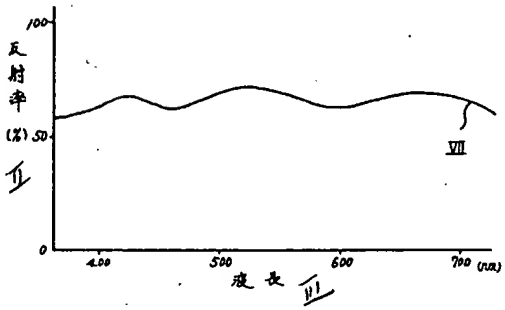
第 7 図



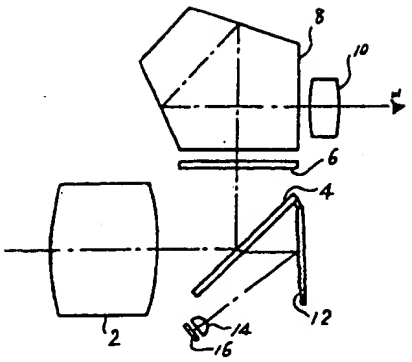
第 6 図



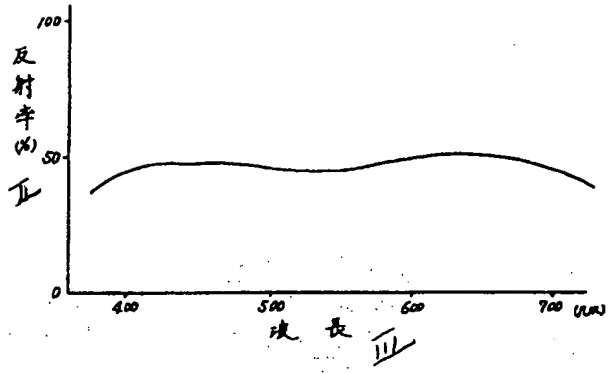
第 8 図



第 9 図 (工)



第 10 図 (工)



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